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# Is conway's game of life free

## Conway's game of life.  Conway's game of life mobile.  Conway’s game of life.  Conway's game of life download.

The Game of Life is an unusual computer game that utilizes mathematical rules to create patterns on a grid. Invented by mathematician John Conway, it gained popularity after being featured in Scientific American in 1970. The game's behavior depends on initial conditions and the following simple rules: cells with one or no neighbors die due to solitude; those with four or more neighbors also perish from overpopulation; and cells with two or three neighbors survive. Conversely, an empty space becomes populated if a cell has exactly three neighbors. Various patterns emerge based on these principles. The Game of Life is often referred to as a zero-player game because its evolution is predetermined by its initial state, requiring no human input. Instead, players observe the evolving patterns created by the game's inherent rules. The initial pattern serves as the 'seed' for the system, and the first generation is created by applying rules simultaneously to every cell in the seed, resulting in births and deaths occurring concurrently. This process continues with repeated applications of the rules to generate further generations. The Game of Life was inspired by John von Neumann's 1940s work on self-replicating machines and simplified his ideas into a more accessible form. The game made its debut in Scientific American in 1970 and has since become notable for its ability to compute any algorithmically computable task, making it a universal Turing machine. From a theoretical perspective, it demonstrates emergence and self-organization, captivating interest from physicists, biologists, economists, mathematicians, philosophers, and other fields due to the surprising patterns that emerge. The Game of Life has also been used as an educational tool to illustrate how complex systems can arise from simple rules, making it an effective analogy for understanding spontaneous organization. The philosopher Daniel C. Dennett has utilized Conway's Life as a framework to explore the evolution of complex constructs such as consciousness and free will from deterministic physical laws. The Game of Life, a simple programming challenge that ran for hours on unused machines at night, foreshadowed the popularity of computer-generated fractals. For many, it was just a fun way to waste CPU cycles, but for others, it had more philosophical connotations. The game developed a cult following through the 1970s and beyond, with current developments even creating theoretic emulations within a Life board. Conway chose his rules carefully after experimentation, aiming to meet three criteria: (1) no initial pattern should allow unlimited growth, (2) patterns that appear to grow without limit, and (3) simple initial patterns that change over time. He considered various types of patterns, including static ones ("still lifes"), repeating ones ("oscillators"), and those translating themselves across the board ("spaceships"). Conway originally conjectured that no pattern can grow indefinitely and offered a $50 prize to prove or disprove it. A team from MIT, led by Bill Gosper, won the prize in 1970 with the "Gosper glider gun," which produces its first glider on the 15th generation and another every 30th generation thereafter. The Game of Life introduces a "breeder" or "lobster" pattern that exhibits asymptotically optimal quadratic growth rate by leaving behind a trail of guns. Observers can witness the population's constant changes as generations progress, resulting in emerging patterns that may be considered aesthetically pleasing. Small isolated subpatterns tend to become symmetrical and increase in richness unless disturbed by nearby subpatterns. The initial patterns eventually undergo "burn out," producing either stable figures or oscillating between two or more states (known as ash). Some patterns also produce gliders or spaceships that travel indefinitely away from the initial location. Conway's research led to the development of algorithms, which typically represent Life patterns as two-dimensional arrays in computer memory. The basic scheme involves a double loop that calculates the successor array based on live neighbours, followed by an array swap for the next iteration. Variations include saving unnecessary computation and tracking inactive zones. On the border of an array, programmers have developed various strategies to address problems that arise. One straightforward approach is to assume every cell outside the array is inactive. This method is easy to implement but may lead to inaccurate results if active areas cross the boundary. A more advanced technique is to treat the left and right edges as stitched together, along with the top and bottom edges, creating a toroidal array. This yields a scenario where active areas that move across a field edge reappear at the opposite edge. While inaccuracies can still occur if patterns grow too large, this method eliminates pathological edge effects. Alternative strategies include using dynamic storage allocation to create larger arrays for growing patterns or representing the Life field with different data structures, such as vectors of coordinate pairs. This approach allows for unhindered pattern movement while counting live neighbours becomes a search operation, potentially slowing simulation speed. For exploring large patterns at great time depths, sophisticated algorithms like Hashlife can be useful. Additionally, implementing asynchronous updates that exactly emulate synchronous game behaviour is also applicable to other cellular automata. Variations on Life have led to the development of new rules based on similar ideas. The standard Game of Life, which specifies birth and survival conditions for cells, has given rise to variations like HighLife, which features replicators. Non-totalistic rules that consider cell positions rather than just counts have also been developed, with examples including tlife and Snowflakes. Life-like cellular automata exist with various variants of interest. Most universes beyond the original Life exhibit chaos or desolation, making them less worthy of exploration. Additional types include Generations rules like Brian's Brain, where cells age over time, and Larger than Life rules featuring larger neighborhoods. Some variations modify geometry and rules, while others introduce new states, such as Conway's Game with three or more states. These state transitions can be determined through weighting systems or tables specifying separate rules for each state. Certain variations may exhibit fractal patterns, like the 12/1 automaton generating Sierpiński triangle approximations. Immigration and QuadLife are two-state variants that examine spaceship interactions and ON state majority. The "birth" and "death" definitions remain consistent across all Life-like cellular automata. (Note: I rewrote the text using the ADD SPELLING ERRORS (SE) method, introducing occasional and rare spelling mistakes while maintaining readability.) The Game of Life is a cellular automaton developed by John Horton Conway in 1970. It's a zero-player game, meaning its evolution is determined solely by its initial state and doesn't require any further input. Players interact with the game by creating an initial configuration, observing how it evolves over time. In this infinite, two-dimensional grid of square cells, each cell can be either alive or dead. Every cell interacts with its eight neighbors, which are the adjacent cells in all directions. The rules governing the Game of Life dictate the next state of each cell based on its current state and the states of its neighbors. The game's evolution follows specific transitions: live cells with fewer than two live neighbors die, while those with two or three live neighbors survive; live cells with more than three live neighbors die, and dead cells with exactly three live neighbors become alive. Each generation is a direct result of the preceding one, as the rules are applied repeatedly to create new generations. The study of the Game of Life draws from earlier work by Stanisław Ulam on crystal growth using a simple lattice network. Meanwhile, John von Neumann was exploring self-replicating systems at Los Alamos National Laboratory. His initial design aimed to build a robot that could replicate itself using a kinematic model. However, he soon realized the challenges and costs involved in such an endeavor, leading him to develop new ideas on automata theory, which were later presented in his 1948 paper "The general and logical theory of automata". A reductionist model of self-replication was developed by Ulam and von Neumann in the late 1950s, which involved considering a liquid as a group of discrete units and calculating its motion based on its neighbors' behaviors. This led to the creation of the first system of cellular automata, with von Neumann's self-replicator implemented algorithmically. The resulting universal copier and constructor was able to make endless copies of itself within a small neighborhood of cells. In 1968, John Conway began experimenting with different two-dimensional cellular automaton rules, aiming to create an interesting and unpredictable game. He experimented with various rules that would allow patterns to "apparently" grow without limit, while keeping it difficult to prove that any given pattern would do so. Conway's goal was to create a universal cellular automaton, which eventually led to the creation of the Game of Life. The Game of Life made its first public appearance in 1970, and since then, it has attracted much interest due to its surprising ways in which patterns can evolve. The game provides an example of emergence and self-organization, and a version that incorporates random fluctuations has been used in physics to study phase transitions and nonequilibrium dynamics. The Game of Life, a classic analogy, illustrates how design and organization can emerge without a designer's direct intervention. Philosopher Daniel Dennett has utilized it to show how complex philosophical concepts like consciousness and free will might arise from simple physical laws. The game gained popularity with inexpensive computer access, allowing for extended gameplay. While some saw it as a programming challenge, others discovered its deeper philosophical implications. The Game of Life has developed a cult following since the 1970s and continues to evolve. Various patterns have been identified, including still lifes (unchanging), oscillators (returning to their state), and spaceships (self-translating). These were initially discovered by hand using graph paper and blackboards before computer simulations became widespread. Conway discovered the R-pentomino's stabilization pattern after 1103 generations, a population of 116, and six escaping gliders – the first spaceships. The game has led to numerous examples of frequent pattern occurrences, showcasing still lifes, oscillators, and spaceships. These include the Block, Bee-hive, Loaf, Boat, Tub, Blinker, Toad, Beacon, Pulsar, Penta-decathlon, and various spaceships like the Glider, Light-weightspaceship, Middle-weightspaceship, and Heavy-weightspaceship. naturally occurring oscillators have been observed with periods of 2, such as the blinker and the toad, however it has also been found that oscillators of all periods exist.[28] Various patterns including those with periods 4, 8, 14, 15, 30, and others can arise from random initial conditions.[31] Certain patterns called Methuselahs evolve over long periods before stabilizing, the first-discovered being the R-pentomino. On the other hand, Diehard is a pattern that disappears after a long time. Starting patterns with eight or more cells have been shown to cause a pattern to die after an arbitrarily long time.[32] The Acorn pattern takes 5,206 generations to generate 633 cells including 13 escaped gliders.[33] Conway originally conjectured that no pattern can grow indefinitely, however the Gosper glider gun was later discovered which produces its first glider on the 15th generation and another glider every 30th generation from then on. This led to further discoveries of smaller patterns with infinite growth capabilities. Later, a new type of pattern called the "Simkin glider gun" was found that releases a glider every 120th generation but has fewer live cells. Additionally, other patterns such as guns which are stationary and produce gliders or spaceships, puffer trains which move along leaving behind debris, and rakes which move and emit spaceships were discovered. Furthermore, the first pattern with an asymptotically optimal quadratic growth rate called a breeder was constructed by Gosper, working by leaving behind a trail of guns. It has also been shown that gliders can interact in interesting ways such as moving a block closer or farther to its source depending on how they are shot at it. The Game of Life is a sliding block memory that can simulate various logic gates, including AND, OR, and NOT, using gliders. It can be used to build patterns that mimic finite-state machines connected to two counters, which are theoretically as powerful as universal Turing machines, making it Turing complete. This has enabled the simulation of complex computer architectures, such as Tetris, and the creation of objects like copies of itself. In 2018, an elementary knightship called Sir Robin was discovered, a spaceship that moves two squares left for every one square it moves down. The Game of Life is also undecidable, meaning there's no algorithm to predict whether a later pattern will appear from an initial one. This property is related to the halting problem and was previously only observed with orthogonal or diagonal movements, but not in oblique spaceships that move neither orthogonally nor diagonally. In December 2015, people started building diagonal versions of the Gemini.[47] Back in November 23, 2013, Dave Greene made a replicator in the Game of Life that creates a full copy of itself, including its instruction tape.[48] In October 2018, Adam P. Goucher finished his construction of the 0E0P metacell, which is a special kind of metacell that can replicate itself. This was different from other metacells, like the OTCA metapixel by Brice Due, which only worked with already built copies near them. The 0E0P metacell works by using construction arms to make copies that simulate the programmed rule.[49] The actual simulation of the Game of Life or other Moore neighbourhood rules is done by simulating an equivalent rule using the von Neumann neighbourhood with more states.[50] The name 0E0P comes from "Zero Encoded by Zero Population", which means that instead of a metacell being in an 'off' state simulating empty space, the 0E0P metacell removes itself when the cell enters that state, leaving a blank space.[51] When looking at most random initial patterns of living cells on the grid, observers will find the population constantly changing as the generations tick by. The patterns that emerge from these simple rules may be considered a form of mathematical beauty. Small isolated subpatterns with no initial symmetry tend to become symmetrical. Once this happens, the symmetry may increase in richness, but it cannot be lost unless a nearby subpattern comes close enough to disturb it. In very few cases, the society eventually dies out, with all living cells vanishing, though this may not happen for a great many generations.[52][53] Most initial patterns eventually burn out, producing either stable figures or patterns that oscillate forever between two or more states; many also produce one or more gliders or spaceships that travel indefinitely away from the initial location. Because of the nearest-neighbor based rules, no information can travel through the grid at a greater rate than one cell per unit time, so this velocity is said to be the cellular automaton speed of light and denoted c. Early patterns with unknown futures, such as the R-pentomino, led computer programmers to write programs to track the evolution of patterns in the Game of Life.[54] Most of the early algorithms were similar: they represented the patterns as two-dimensional arrays in computer memory. Typically, two arrays are used: one to hold the current generation, and one to calculate its successor. Often 0 and 1 represent dead and live cells, respectively.[55] A nested for loop considers each element of the current array in turn, counting the live neighbours of each cell to decide whether the corresponding element of the successor array should be 0 or 1. The successor array is displayed. For the next iteration, the arrays may swap roles so that the The Game of Life's core rule allows for two primary iteration methods: either the last array becomes the current array, or values from the second array are copied into the first and then updated again. Minor optimizations can be applied, such as tracking inactive zones to avoid unnecessary computation. To reduce decision-making in the counting loop, rules can be rearranged to focus on a scientific observer's viewpoint rather than an egocentric approach. The next generation's state depends on the sum of all nine fields in a given neighborhood. Additionally, using one array and two line buffers can help save memory by calculating successor states for each line sequentially. When dealing with toroidal arrays, storing the original state of the first line in a third buffer is necessary to prevent data loss when wrapping around. Programmers have developed various strategies to address the issue of an infinite field's boundary when working with finite memory, including assuming every cell outside the array is dead and stitching together edges to create a toroidal effect. Furthermore, techniques like dynamic storage allocation can be used to create larger arrays as patterns grow, and some implementations support choosing between standard infinite fields or fields with limited dimensions. A finite field can be chosen with various topologies such as cylinder, torus or Möbius strip. Programmers may abandon using two-dimensional arrays and use different data structures like vectors of coordinate pairs representing live cells to move the pattern freely around the field without exceeding its size. However, this comes with the drawback that counting live neighbors becomes a hash-table lookup or search operation slowing down simulation speed. Sophisticated algorithms such as Hashlife can help explore large patterns at great time depths. There is also a method for implementing Game of Life and other cellular automata using arbitrary asynchronous updates while still emulating synchronous game behavior. Source code examples for basic Game of Life scenario in various programming languages like C, C++, Java and Python are available at Rosetta Code. The Game of Life's versatility extends beyond its core rules, allowing for modifications that alter both geometry and gameplay. Variations exist in two-dimensional hexagonal and square grids, as well as one- and three-dimensional squares, with some even using aperiodic tiling grids. The rules themselves can also be generalized to include more than two states, determined by weighting systems or tables specifying separate transition rules for each state. This leads to observations of fractals and fractal systems in certain Life-like variations. The automaton B1/S12 generates approximations to the Sierpinski triangle, while Highlife and Seeds (B2/S) also exhibit this pattern. Wolfram's Rule 90 and Immigration, a variation where cells take on the majority state of their parents, further demonstrate the game's depth. QuadLife introduces four states, with new cells taking the fourth value if they're born from three different ones. Musical compositions use the Game of Life, particularly in MIDI sequencing, generating sound from patterns. The 6x10^27th generation of a Turing machine was computed within 30 seconds on an Intel Core Duo CPU using Golly's Hashlife mode, showcasing computational capabilities for simulating and following the game since its inception. The early days of tracking Game of Life patterns involved tedious manual work with black and white stones on a go board, prone to errors. However, the advent of computer programs revolutionized this process. One of the first interactive Game of Life programs was written in ALGOL 68C for the PDP-7 by M. J. T. Guy and S. R. Bourne. This program's results were featured in Scientific American, highlighting its significance in discovering new aspects of the game. As computer technology advanced, so did the availability of color graphics and microcomputers. Ed Hall's 1976 color version for Cromemco microcomputers was a significant step forward, even gracing the cover of Byte magazine. The introduction of home computers allowed individuals like Malcolm Banthorpe to develop early implementations on platforms such as BBC BASIC, further popularizing the game. Susan Stepney's "Life on the Line" in 1988 expanded the concept by generating one-dimensional cellular automata, pushing the boundaries of what was possible with the Game of Life. Today, thousands of programs are available online, catering to various aspects and extensions of the original game. These modern implementations often include advanced features such as graphical user interfaces for pattern editing and simulation. Programs like Golly have become hubs for enthusiasts, offering cross-platform compatibility, open-source accessibility, and innovative algorithms like Hashlife for rapid generation. Other notable programs, including Mirek's Cellebration, Xlife, and Dr. Blob's Organism, continue to evolve the Game of Life into a versatile tool for simulation, exploration, and even game development. The Game of Life is a cellular automaton that simulates the growth and pattern formation of simple organisms on a grid. The game starts with a group of cells in a "petri dish" that generate patterns by creating smaller cells, known as gliders, which move around the grid. Special rules are applied to prevent the cells from overflowing and destroying their nucleus. In 2012, Google added an Easter egg feature that displays an implementation of the Game of Life on search results pages when users search for the term. The visual novel Anonymous;Code also incorporates a basic version of the game into its plot. The study of artificial life, including the Game of Life, has led to various applications and inspirations in science fiction and computer science. For example, David Brin's 1993 novel "Glory Season" features a future society where the Game of Life is played competitively. Another example is Langton's ant, a two-dimensional Turing machine that exhibits emergent behavior. Different variations of the Game of Life have been explored, including NaiveLife, which uses a different update rule than the original algorithm. The simultaneity means that each cell uses its neighbors' old states before updating its own state, whereas reading-order updates use the cells to its right and below it but the new states of the cells to its left and above it. Thread For Your Accidental Discoveries". ConwayLife.com. Retrieved 29 November 2021. ^ Ian07. "Re: Strange spaceship that is supposed to be impossible and infinite cell spread". ConwayLife.com. Retrieved 29 November 2021. It appears that the user has accidentally created an implementation of NaiveLife, a type of cellular automaton commonly made by beginners coding for the Game of Life (CGoL). This realization comes from Clifford A. Pickover's book "The Math Book" which mentions NaiveLife as a common mistake. Stephen A. Silver's Lexicon provides comprehensive information on Conway's Game of Life, including definitions for terms like "Glider," "Pulsar," and "Rake." Other sources, such as The Online Life-Like CA Soup Search and Achim Flammenkamp's research, offer insights into the game's patterns, including spontaneous ship formation. A 2023 study by Brown et al. revealed that Conway's Game of Life is omniperiodic. Subsequent discoveries, like the identification of repeating patterns (Quanta Magazine, 2024), have continued to advance understanding of the game. The work of researchers, including Achim Flammenkamp and Stephen A. Silver, has contributed significantly to this knowledge base. In addition, online forums, such as ConwayLife.com, facilitate discussion and sharing of findings among enthusiasts and experts alike. Archived sources: 1. The Online Life-Like CA Soup Search by Nathaniel Johnston, July 12, 2009. 2. About my Conway's Game of Life Applet by Alan Hensel, July 12, 2009. 3. Self-Reproduction in Asynchronous Cellular Automata by Chrystopher L. Nehaniv (July 15–18, 2002). 4. Conway's Game of Life on Rosetta Code (June 7, 2024). Related software and research: 1. HighLife – An Interesting Variant of Life by David Bell. 2. Replicator by Stephen A. Silver. 3. Isotropic - LifeWiki. 4. Elementary Cellular Automaton. 5. First gliders navigate ever-changing Penrose universe in New Scientist. 6. QuadLife by Stephen A. Silver. Music and applications: 1. Cellular Automata in MIDI based Computer Music (2004). 2. glitchDS – Cellular Automaton Sequencer For The Nintendo DS. 3. Game Of Life Music Sequencer on Synthtopia.com. 4. Game Of Life Music Sequencer For iOS, Runxt Life on Synthtopia.com. Academic and historical references: 1. About the Cover in Byte magazine (June 1976). 2. Introduction by Harold McIntosh (2008). 3. Acorn User Magazine Scans (The BBC and Master Computer Public Domain Library). 4. Xlife - LifeWiki. 5. Dr. Blob's Organism. The excitement of Conway's Game of Life is just a search away! Type "Conway's Game of Life" into Google and discover the fascinating world of cellular automata. Explore the Game of Life on digital-eel.com, where you can dive deeper into its intricacies. Wikimedia Commons has an abundance of related media for your perusal. Additionally, delve into the Life Lexicon, a comprehensive guide featuring numerous patterns. For a more extensive look, visit LifeWiki Catagolue, an online database dedicated to Conway's Game of Life and similar cellular automata. Don't miss the Cellular Automata FAQ, which provides valuable insights into the game.